SMAGRINET
POWERING SMART GRID EXPERTISE IN EUROPE

General Introduction of the Module I

Artificial Intelligence (AI) in Smart Grids

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Brief Description of the Topic

Artificial Intelligence in Smart Grids

1. Data representation, exploration and visualization
2. Linear and nonlinear models
3. Deep learning
4. Generalization issues in modelling
5. Model assessment and selection
6. Unsupervised learning
7. Applications of AI in smart grids

Applications of AI in smart grids

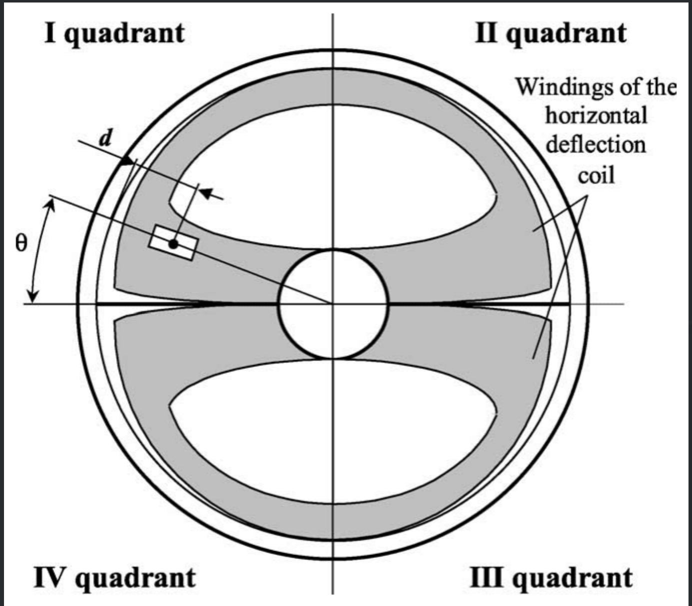
1. Energy demand management
2. Load and power prediction
3. Consumer and consumption insights
4. Energy trading
5. Energy management systems
6. Predictive maintenance
7. Cyber security, power system protection

Kaunas University of Technology

Department of electrical power systems

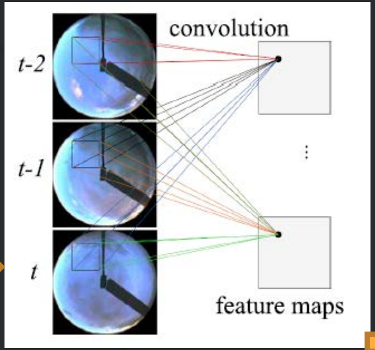
1. Extensive research experience in applied artificial intelligence.
2. Lot of research experience and practice in stability of electrical systems, electrical machines, electric and magnetic fields, renewable energy sources, hybrid energy systems management, energy market.
3. Many projects concerning applications of AI in electrical power systems and energy market.

AI application example: Adjusting magnetic field of CR



Adjusted with	Machine (%)	Human expert (%)
1 shunt	28.2	1.6
2 shunts	65.3	5.5
3 shunts	4.0	0.0
4 shunts	0.5	88.9
Failed	2.0	4.0

ML-based forecasting of floating PV power generation

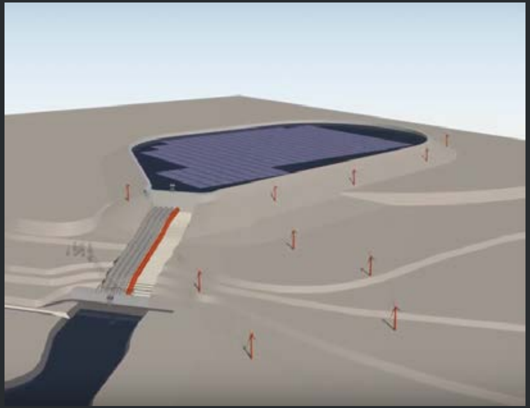


t+n weather parameters

t-n actual data (generation)

Forecast model

PV generation forecast



Kruonis pumped storage plant

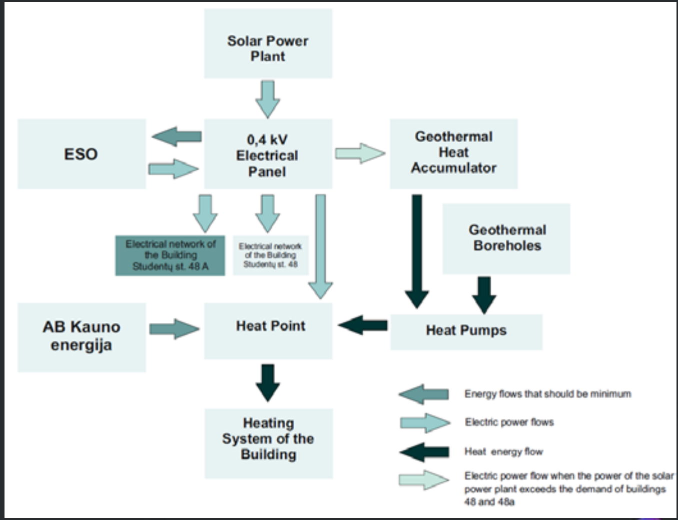
Efficient control of energy flows in hybrid energy system

Technical parameters

- 380 kW solar power plant;
- 150 kW heat pump system “primer-water”
- Accumulator of thermal energy in water;

Supplies

- 20 % of the needed electric power;
- 2/3 of the necessary thermal power (heating area > 14,000 m2);
- Reduces the CO2 emission by 6,000 t/year;
- Payback period 8.4 years.




The accumulator of thermal energy in water


380 kW solar power plant

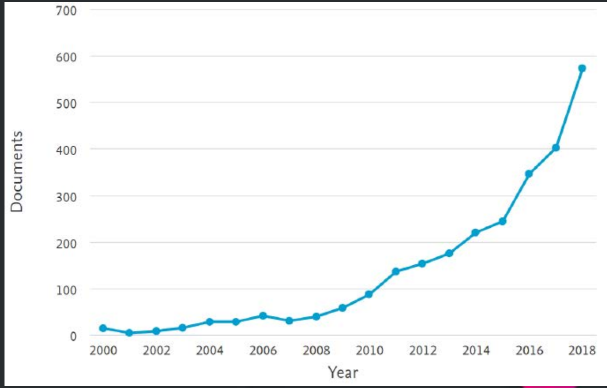
AI in KTU study programme “Electric power engineering”

1st semester	2nd semester	3rd semester	4th semester
P176M001 Artificial Intelligence in Smart Grids	T140M163 Reliability and Quality of Power Systems	T140M100 Electrical Equipment Testing and Fault Diagnostics Methods	
T140M122 Cybernetic Security of Power Systems	T140M165 Power System Planning	*Alternatives*	
T140M261 Power Systems Operation and Control	*Alternatives*	*Expert competence (free choice) or MA+ competence*	T000M041 Final Degree Project
T140M266 Computer Modelling of Electric Power Systems	*Expert competence (alternatives) Or MA+ competence*	T000M040 Research Project 2	
Expert competence (alternatives) Or MA+ competence	T000M039 Research Project 1		

Why is AI an Important Part of the Smart Grid?

1. Growing penetration of renewable energy sources requires accurate forecasting and efficient decision making.
2. Smart sensors, and IoT technologies have enabled big data and brought new challenges and opportunities.
3. AI and big data-based techniques allow finding efficient solutions to these tasks (see the graph).

The growth in the number of articles related to ML in energy systems during the past two decades



“State of the art of machine learning models in energy systems, a systematic review“, Energies.

Knowledge the Module Provides

- After completion the course, the student:
  - Understands the principles of machine learning and has knowledge of main machine learning methods;
  - Is able to create and validate AI-based models;
  - Can use AI-based models for solving practical tasks arising in smart grids;
  - Can read and comprehend research articles in this area.

Dresden University of Technology

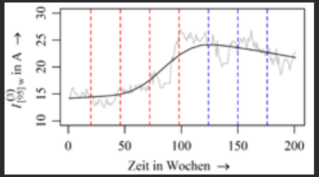
Chair of Electrical Power Supply

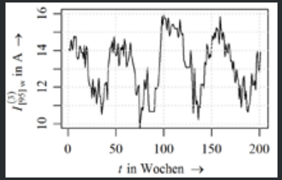
The Chair of Electrical Power Supply includes five research groups:

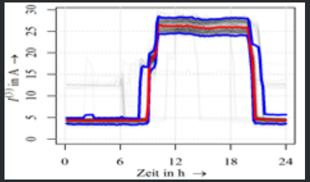
1. Energy converters and instrument transformers
2. Planning and operation of grids
3. Protection and control technology
4. Smart Grid
5. Power Quality (PQ)

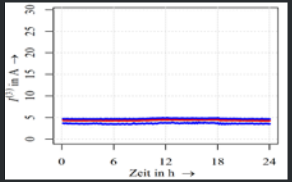
Data mining in Power Quality data:

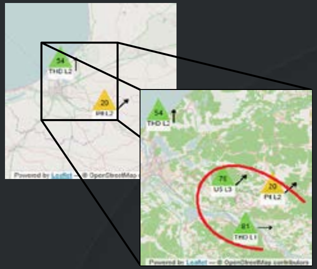
1. Time dependent variation detection (trend, seasonally, daily|weekly cycles)
2. Pattern recognition for different consumer types
3. PQ index system
4. Abnormal behavior detection in continuous PQ parameters
5. PQ event detection and classification
6. Correlation analysis
7. Other

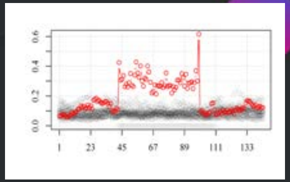












Why is AI an Important Part of the Smart Grid?

Motivation

- High penetration of renewable energy sources
- Fast development of digital technology and cloud computing
- Extensive measurement campaigns and permanent monitoring (smart meters)
- Exponential growth of data (“Big data”)

➢ A novel framework and techniques (AI) to excavate useful information in fast and comprehensive way are required

➢ New vision for engineers to perceive and control the traditional electrical system and makes it smart

Data analysis and application examples

Data analysis is basis for discovering valuable information and supporting the decision-making.

Data analysis concepts:

- Statistics
- Data mining
- Artificial intelligence
- Machine learning
- Deep learning

Application examples:

- Customer behavior analysis
- Demand forecasting
- Renewable energy forecasting
- Electric device state estimation
- Power quality
- And many other

Knowledge the Module Provides

Module 1: Artificial Intelligence in Smart Grids

1. Introduction to AI

(Definition on AI, overview of ML methods, general methodology, application examples)

2. Forecasting methods

(Classification of forecasting methods, i.e. forecast horizon and input data, time series models, explanatory models, dynamic regression models, application examples, e.g. PQ trend detection)

3. Linear and non-linear models (KTU)

4. Generalization issues (KTU)

5. Application example: Power Quality anomaly detection

(I & U harmonics, feature-transformation, robust threshold, sliding window, anomaly classification)

6. Application example: Power Quality event detection

(Notch detection, feature engineering, Decision tree, One-class SVM)

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